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<p>(21) International Application Number: PCT/US98/18419 (22) International Filing Date: 3 September 1998 (03.09.98) (30) Priority Data: 60/058,195 8 September 1997 (08.09.97) US (71)(72) Applicant and Inventor: SIMON, Jerome, H. [US/US]; 70 Sumner Street, Newton Centre, MA 02159 (US). (74) Agents: KAYE, Harvey et al.; Perkins, Smith & Cohen, LLP, One Beacon Street, Boston, MA 02108 (US).</p>		<p>(81) Designated States: US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>
<p>(54) Title: ARCHITECTURAL LIGHTING DISTRIBUTED FROM CONTAINED RADIALLY COLLIMATED LIGHT AND COMPACT EFFICIENT LUMINAIRES</p> <p>(57) Abstract</p> <p>From a quasi point source (2), light distribution means produce a selected one or ones of broadly distributed ambient light, non-shadowing task illumination, multi-beam display lighting (99), projective lineal lighting and projective surface washing illumination linearly or radially distributed. Collimation optics shape light (26) from a quasi point source (2) into a disc of selected axial thickness (64). The distribution optics (59) may reflect or refract light to direct and shape it for a particular architectural illumination requirement.</p> <div data-bbox="690 1199 1360 1906"><p>The diagram illustrates a lighting fixture within a rectangular enclosure. At the top center, a light source labeled 85 emits a series of light rays, labeled 99, which are directed downwards. These rays strike two vertical rectangular surfaces, each labeled 104, positioned on either side of the center. The rays reflect off these surfaces and converge towards a circular area on the bottom surface of the enclosure. The entire fixture is depicted within a perspective view of a box.</p></div>		

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**ARCHITECTURAL LIGHTING DISTRIBUTED FROM CONTAINED
RADIALLY COLLIMATED LIGHT AND COMPACT EFFICIENT
LUMINAIRES**

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Cross Reference to Related Applications

This application is a continuation-in-part of my co-pending application. Serial No. 08/201,466 filed February 25, 1994, which was a continuation-in-part of my application Serial No. 08/006,623, filed Jan 21, 1993, now abandoned.

10 This application is also based upon and claims the priority of Provisional application Serial No. 60/058,195 filed September 8, 1997.

Field of the Invention

The present invention relates generally to lighting systems and arrangements, and, more particularly, to a system for producing shaped and directed light from a
15 quasi point source to provide broadly distributed ambient light, non-shadowing task illumination, multi-beam display lighting, projective lineal lighting and projective surface washing illumination lineally or radially distributed as well as to provide efficiently distributed illumination from a compact luminaire and to provide lighting which reduces the heat level above the light source.

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Background of the Invention

The present invention relates to improved use of radiant energy from a quasi point source. The present specification primarily discusses collimation and shaping of visible light, since this is the collimation application for the invention
25 at the present time, but other forms of radiant energy, for example infrared energy for heating, could be similarly distributed. The quasi point source may conveniently comprise a metal halide lamp. For simplicity in description, the terms radiant energy and light will be used interchangeably in the present description. In my patent application Serial Number 08/006,623, I have described
30 means for utilizing collimation means to provide radial collimation for a quasi point source, and producing a cylinder of light which is transmitted for distribution by further means. The present invention provides advancements in distribution and shaping of light utilizing distribution optics in conjunction with radial collimation means. In further embodiments, further improvements are
35 provided wherein an "f" number is minimized, where the "f" number is

inversely proportional to efficiency of light capture of the source by the radial collimation means.

There is a need to provide high intensity, efficient, directed, non-glare illumination to cover a large area or a plurality of spaces. Typical current solutions require the use of a plurality of sources such as separate bulbs in separate down-lights. One system may need to contain one group of light bulbs of a first wattage as well as other bulbs of differing types in order to meet particular lighting requirements. For example, a spotlight is almost invariably provided with an incandescent source, while relatively low power ambient lighting is provided by fluorescent tubes. This results in complexity and expense in installation and in inconvenience and expense in maintenance.

Typical prior art systems for distributing light from a source commonly lack flexibility in the number of different directions in which light may be directed from a single source. They are also characterized by complexity and lack of efficiency. In most existing lighting systems, energy is gathered by a parabolic or ellipsoidal reflector and distributed in a conical shape. The system of the present invention does not need such reflectors as a collimation means of collection. A radially formed collimation device feeds modulation means. The present invention provides for a simplicity in construction and compactness in layout for any of a number of different types of systems. Systems constructed in accordance with the present invention may provide for lighting the interior of a room, the exterior of a vehicle or other space.

In making devices using radially collimated light, it would be highly desirable to provide lighting fixtures able to be constructed in flat or thin shapes. A significant characteristic in many applications is thickness. Means that capture collimated light for further distribution are referred to in the present invention as distribution optics.

Means that collimate light in at least a radial degree of freedom are referred to in the context of the present invention as collimation optics. In typical prior art systems, in order to capture a desired percentage of radially collimated light for further distribution, means which may be viewed as corresponding to the distribution optics must of necessity be significantly thicker in an axial direction than the prior art means which correspond to the present invention's collimation optics. This will result in a light distribution means constructed in accordance with prior art principles for a particular light shaping other application being

significantly thicker than such means constructed in accordance with the present invention. The present invention will allow integration of means for producing a given light distribution into an architectural member. For example, a shelf may be provided which produces illumination on areas or items below it. A ceiling or wall panel that would be otherwise totally impractical due to its thickness may be produced with dimensions for maximizing flexibility in its utilization. Use of a high efficiency high intensity light source is permitted from which light may be distributed over a broad area or into a plurality or separate volumes with minimized glare and lamps not being visible.

Summary of the Invention

It is therefore a general object of the present invention to provide an illumination means including radial light collimation optics, containment optics and optics for distributing and shaping collimated light to illuminate the interior or exterior of an architectural space, which could be a vehicle.

It is an additional general object of the present invention to provide an illumination means of the type described wherein the collimation, containment and distribution optics are matched to each other to provide maximum efficiency of light distribution from the quasi point source.

It is also a general object of the present invention to provide a highly controlled light distribution system wherein optics are provided by the system, and not by a source such as a flood-lamp which includes both light emitting and reflecting means, whereby disposability of portions of a lighting system is reduced.

It is another object of the present invention to provide illumination means of the type describe to reduce the number of sources to illuminate a broad space by permitting the use of a single, high efficiency, high intensity source.

It is also a general object of the present invention to reduce the complexity of a light distribution system by elimination of the need to utilize differing types of lamps for differing types of lighting, e.g. task, ambient or display.

It is an additional general object of the present invention to provide an illumination means of the type described to minimize the complexity of maintenance by eliminating the need to use different types of bulbs for different types of illumination.

It is a specific objective of the present invention to provide an illumination system of the type described in which bulbs providing illumination are not visible to observers in the illuminated space.

It is an object of the present invention in one form to provide for a fixture,
5 which may be attached to a wall, ceiling or other architectural surface, which is of minimized thickness with respect to the proportion of the light captured from the source for distribution.

It is an objective of the present invention in a further form to provide for a fixture which is of minimized thickness with respect to the proportion of the light
10 captured from the source for distribution by virtue of minimized axial dispersion so that the fixture which may be embedded in a wall, ceiling or other architectural surface.

It is a still further objective of the invention to provide a system of the type described in which inputs from more than one source may be combined, one
15 input of which could be solar.

It is a still further specific objective in a the form of system of the type described to permit the combination of different light sources which may have differing "warm" or cool" spectra.

It is also an object of the present invention to Provide illumination means of
20 the type described which may be embodied in an low profile architectural devices with respect to a surface to which it is mounted.

It is a more particular object of the present invention to provide a system in which the axial dimension may be minimized while maintaining efficiency in capture of radiation by distribution optics that receive radially collimated light
25 from collimation optics.

It is another object to provide illumination means of the type described in which the distribution optics may provide a plurality of different forms of illumination or separately directed volumes of light of a similar type of illumination.

It is also another object to provide illumination means of the type described in
30 which the containment optics and or the distribution optics may be formed to receive and transmit a plurality of different forms of illumination or separately directed volumes of light of a similar type of illumination.

It is a further object of the present invention in one form to provide compound radial collimators to provide highly efficient capture of radiant flux from the source.

It is yet another object of the present invention to a system of the type described in which light having at least another forms of collimation provided for distribution in addition to radially collimated light so that different types of illumination, e.g. task or ambient, may be provided from one light distribution means.

It is another specific object of the present invention in one form to shape radially collimated light in a continuous lineal beam, whereby convention "scalloping" of a light pattern produced by prior art distribution systems may be avoided.

It is also an additional object of the present invention to provide illumination systems of the type described in which collimation, containment and/or distribution optics may be segmented, whereby additional ability for providing a plurality of separately shaped light segments is provided.

It is another object in illumination systems of the type described to spread illumination from an aperture in illumination means of the type described, whereby glare is reduced.

It is still another object to provide illumination means of the type described which can shape light to meet constraints of a particular environment by selection of interacting forms of collimation and distribution optics.

It is also an another object of the present invention to provide illumination systems of the type described in a panel which is evenly illuminated and which can function as an artificial skylight.

It is also a further object in one form to provide light distribution means of the type described wherein light from more than one quasi point source may be mixed and distributed.

An object of the present invention is to provide efficiently distributed illumination from a compact luminaire-type of lighting.

Another object of the present invention is to provide a lighting arrangement having the ability to vary the intensity of light that is applied to architectural surfacing.

Another object of the present invention is to provide evenly and broadly distributed light on surfaces (such as ceilings) that are within 3 feet from the top of the luminaire.

Another object of the present invention is to provide a lighting arrangement
5 having the ability to vary the crosssectional brightness of the light patterned on architectural surfaces.

Another object of the present invention is to provide mechanisms for variably dividing light from a luminaire to provide a proportionate ratio of brightness to ceilings and brightness to floors.

10 Another object of the present invention is to provide a mechanism for creating interchangeable light patterns on floors and ceilings.

Another object of the present invention is to optically radiate heat away from high temperature light sources (such as quartz halogen) in order to lower the ambient operating temperature in proximity to the light source.

15 Another object of the invention is to provide high efficiency and high performance lighting from a low cost luminaire.

Briefly stated, in accordance with the present invention, there is provided an illumination means including radial light collimation optics, containment optics and distribution optics for shaping light to illuminate space. The radial
20 collimation means is formed to shape light from a quasi point source into a shape which may be viewed as a cylinder or as a disc extending in a radial direction and having a thickness in the axial direction. The containment optics contains and directs light efficiently to the distribution optics. The containment optics controls axial dispersion with respect to distance from the collimation optics.
25 Light is contained within the axial dimension to limit axial dispersion. This provides the capability to maintain efficiency and, where desired, to minimize the axial dimension of the system of the present invention. Also, the size of the distribution optics, particularly in the axial dimension may be minimized while still providing for maximum capture of light. Distribution optics are radially
30 outward of the collimation means. Containment optics may be a physical bridge between collimation optics and distribution optics. The containment means may be a structural member. The distribution optics may be concentric with the radial collimation means, or may comprise discrete elements. The distribution optics modulate light, directing and shaping it to fill selected spaces. Distribution optics
35 may be formed to spread illumination from an aperture, whereby glare is

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Figure 18 illustrates containment optics including two parts, a solid bridge linking collimation optics and distribution optics as well as a containment ring lens.

Figure 19 illustrates physical bridging from collimation means to
5 containment means.

Figure 20 is an axonometric view with diametric cross section of a compact system suited for distributing light on a surface for secondary illumination.

Figure 21 is an elevation of the embodiment of Figure 20 installed to an architectural surface.

10 Figure 22 is an illustration similar to that of Figure 20 illustrating an alternative embodiment in which distribution optics are reflective rather than refractive.

Figure 23 is a an elevation in cross section of a collimation and distribution means employing a light containment optics between the collimation and
15 distribution optics.

Figures 23A and 23B illustrate alternate forms of exit apertures from distribution optics.

Figure 24 is an axonometric view of a system mounted to a transmissive architectural panel.

20 Figure 25 is a perspective view illustrating an embodiment according to either of Figures 23 or 24 in use.

Figure 26 is an axonometric view with a diametric cross section illustrating a system similar to that of Figure 23 which utilizes a collimation optics of Figure 5.

Figure 27 and 28 are a cross sectional elevation and an axonometric view of a
25 system with segmented distribution optics suitable for installation to an architectural panel.

Figure 29a and 29b illustrate alternative light exit means for inclusion in the embodiment of Figures 27 and 28.

Figures 30 and 31 are a cross sectional elevation and an axonometric view of
30 another form of system with segmented distribution optics suitable for installation to an architectural panel.

Figure 32 is a perspective view illustrating an embodiment according to either of Figures 30 and 31 in use.

Figure 33 illustrates alternative light exit means for inclusion in the embodiment of Figures 30 and 31 for changing the shape of light directed from the linear distribution optics segments.

Figures 34 and 35 are a cross sectional elevation and an axonometric view of another form of system with multiple, concentric distribution optics members of differing axial dimensions suitable for installation to an architectural panel.

Figure 36 is a perspective view illustrating an embodiment according to either of Figures 34 and 35 in use.

Figures 37 and 38 are a cross sectional elevation and an axonometric view, partially broken away, of another form of system with reflective distribution optics members.

Figure 39 is a partial detail view illustrating alternative exit means for the light distribution means of Figure 37.

Figures 40, 41, 42 are each an axonometric view with diametric cross section of a separate embodiment of distribution optics containing multiple light directing elements, with Figures 41 and 42 illustrating solid containment optics.

Figures 43 and 43A are a cross sectional elevation and an axonometric view, partially broken away, of another form of system with reflective containment optics and refractive ring distribution optics members.

Figure 44 is a partial cross sectional detail illustrating an alternative to the embodiment of Figure 43 in which the distribution optics comprises multiple refractive members.

Figure 45 is a cross sectional elevation of an embodiment incorporating concentric refracting rings for segmenting transmitted light in the distribution optics.

Figures 46 and 47 are a cross sectional elevation and an axonometric view of another form of system suitable for installation to an architectural panel with segmented reflective distribution optics;

Figures 48 and 49 are a cross sectional elevation and an axonometric view of another form of system suitable for installation to an architectural panel with segmented reflective distribution optics wherein shadow eliminating light patterns are provided.

Figures 50 and 51 are each a perspective illustration of a system according to the present invention providing both radial and cylindrical collimation and suitable for inclusion in architectural panels as well as having the ability to be

suspended in space and wherein containment means are shaped to match the output from collimation means.

Figures 52, 53 and 54 are each a perspective view of a different form of system which can be utilized as a table lamp and wherein a different form of distribution optics provides a particular form of light distribution.

Figure 55 is a perspective view of a system similar to that of Figures 52-54 but wherein multiple forms of collimation are provided.

Figure 56 is a partial detail view of Figure 55, partially broken away, illustrating collimation optics means for delivering light.

Figure 57 is an axonometric view of an embodiment in which distribution optics comprises a parabolic or ellipsoidal reflector, which may have a flat, spherical or aspherical surface in the axial, or vertical, dimension.

Figure 58 is a plan view of an embodiment in which the collimator in collimation optics is modified to provide conventional collimation within the segment which is not reflected.

Figure 59 is a cross sectional plan view of an embodiment in which a reflector intercepts forwardly directed radially collimated light and redirects it toward the distribution optics.

Figure 60 is a cross sectional plan view of a system including a horizontally disposed lamp providing radiant energy.

Figure 61 is an axonometric illustration of a system including a solid block of refracting material in the distribution optics portion is formed.

Figures 62 and 63 are respectively an axonometric and a plan illustration of embodiments respectively corresponding to Figures 59 and 59 respectively and further including means for bi-directional transmission in a given planar degree of freedom.

Figure 64 is an axonometric illustration of an embodiment which can be contained in the envelope of a rectangular parallelepiped and comprises multiple light sources.

Figures 65, 66 and 67 each show different forms of exit means that may be included in the embodiment of Figure 64.

Figure 68 is an alternate form of the embodiment of Figure 64 continuous contours may be used to shape the boundary of the distribution optics and exit means.

Figure 69 is an axonometric view, partially broken away wherein distribution optics comprises a shaped, axially extending band surrounding the radial collimation means.

Figures 70 and 71 are a cross sectional elevation and an axonometric view, partially broken away of another form of system suitable for installation to an architectural member comprising a ceiling panel.

Figures 72 through 75 are each a view of means for mixing light from more than one source for distribution in accordance with the present invention.

FIG. 76A is a cross-sectional view of an embodiment of the present invention showing a circular luminaire with the parts positioned for mono-directional lighting.

FIG. 76B is a cross-sectional view of the circular luminaire of FIG. 76A with the parts positioned for bi-directional light.

FIG. 77A is a cross-sectional view of a circular luminaire (similar to the one shown in FIGS. 76) with a variation in the cross-sections of the reflectors and showing the parts positioned for mono-directional lighting.

FIG. 77B is a cross-sectional view of the circular luminaire of FIG. 77A with the parts positioned for bi-directional lighting.

FIG. 78A is an isometric view of a luminaire containing elements for variably segmented illumination into bi-directional lighting.

FIGS. 78B, 78C, 78D are plan views of the luminaire shown in FIG. 78A illustrating changes in rotational relationships required for altering the ratio of brightness or pattern in the segmented illumination.

FIG. 79A is a cross-sectional view of a luminaire whose components are positioned for one type of cross-sectional brightness of the projected light emanating from the luminaire lighting.

FIG. 79B is a cross-sectional view of the luminaire of FIG. 79A whose components are positioned for another type of cross-sectional brightness of the projected light.

FIGS. 80A and 80B are cross-sectional views of a luminaire whose components are variably positioned in relation to each other for varying the ratio of segmentation of light as well as changing the cross-sectional brightness of the beam.

FIG. 81A is a cross-sectional view of a luminaire as shown in FIG. 76A with the addition of optical elements which further control light distribution and resulting diffusion.

FIG. 81B is a cross-sectional view of a luminaire similar to the embodiment shown in FIG. 81A, providing further light control using a movable reflector.

FIG. 81C is a cross-sectional view of the luminaire shown in FIG. 81B in which the movable reflector is in a different position.

FIG. 81D is a cross-sectional view of a luminaire similar to the embodiment shown in FIGS. 81C and 81D which further includes a curved lower reflector, with the movable reflector in an upper position.

FIG. 81E is a cross-sectional view of the luminaire shown in FIG. 81D with the movable reflector shown in a lower position.

FIG. 82A is a partial cross-sectional view illustrating various components of a circular luminaire that provide an alternate method of changing the ratio of brightness of illumination projected toward ceiling and floor.

FIG. 82B is an isometric view of a luminaire similar to that of FIG. 82A showing further details including the structure for moving the reflector.

FIG. 83 is a cross-sectional view of a luminaire similar to FIG. 81 illustrating the use of the components to lower the operating temperature of the area surrounding the lamp.

FIG. 84 is a schematic view of a torchierre lamp which has heat reduction and light distribution functions.

FIG. 85 is a cross-sectional view showing an alternate reflector shape to that shown in FIG. 76A.

FIG. 86A is a cross-sectional view of a circular luminaire having a primary reflector comprised of geometrically or randomly placed concave or convex surfaces.

FIGS. 86B and 86C are partial isometric views of primary reflectors showing two types of surfacing which may be used with the circular luminaire of FIG. 86A.

FIG. 87 is a cross-sectional view of a luminaire showing the reflector in the form of spaced slats and an upper reflector above the light source.

FIG. 88 is a cross-sectional view of a luminaire showing two reflectors and an upper reflector above the light source.

FIG. 89A is a cross-sectional view of a radially directed lighting arrangement depending from a ceiling and having outer refracting surfaces with a reflector shown in its lower position.

FIG. 89B is a cross-sectional view of the arrangement shown in FIG. 89A with the reflector shown in a higher position.

FIG. 89C is an isometric view of the arrangement shown in FIG. 89A.

FIG. 89D is an isometric view of the arrangement shown in FIG. 89B.

FIG. 89E is an isometric view similar to FIGS. 89B and 89C, showing a track mounted arrangement.

FIG. 89F is an isometric view similar to FIGS. 89A and 89B, showing a track mounted arrangement.

FIG. 90A is an isometric view of a negatively fluted reflector.

FIG. 90B is an isometric view of a positively fluted reflector.

FIG. 90C is a broken isometric view of a serially concave reflector.

FIG. 90D is a broken isometric view of a serially convex reflector.

FIG. 91 is a broken isometric view of a double reflector with slots.

FIG. 91B is a broken isometric view of a double reflector with slots and a ring wedge prism.

FIG. 92A is a broken isometric view of a double elongated reflector with slots and arranged for longitudinal movement.

FIG. 92B is an isometric view of a double elongated reflector with slots and arranged for circumferential movement.

FIG. 92C is an isometric view of a double elongated reflector with holes and which may be arranged to move longitudinally and/or radially.

FIG. 93 is an isometric view of a bowl-shaped double reflector with holes.

FIG. 94 is an isometric view showing one manner of connecting the reflector with other structure without producing shadows from the support structure.

FIGS. 95A, 95B and 95C are diagrammatic views of three different positions of a light source with respect to collimating means in an arrangement where they are movable with respect to each other along a center axis.

FIG. 96 is a schematic isometric view of a room having track mounted lighting using the types shown in FIGS. 89A, 89B, 89C, 89D, 89E and 89F.

Description of the Preferred Embodiments